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## SPECIFICATION

### TITLE OF THE INVENTION

MEMORY SYSTEM AND CONNECTING MEMBER

### BACKGROUND OF THE INVENTION

The present invention relates to a technique of mounting plural memory modules, specifically to a technique effective for use in a memory system that mounts memory modules on a mother board through sockets and connects each of the memory modules with a memory controller in an equal distance.

The techniques relating to sockets or connectors for memory modules are disclosed, for example, in the Japanese Published Unexamined Patent Publication No. Hei 10(1998)-3971, Hei 11(1999)-40294, Hei 10(1998)-335546, Hei 8(1996)-314800, Hei 4(1992)-144160 which corresponds to U.S. Patent Publication No. 5,191,404, and so forth.

The Japanese Published Unexamined Patent Publication No. Hei 10(1998)-3971 discloses a technique that when the wirings between the sockets for memory modules are lengthy, the wirings are easily influenced by noises from adjacent signal wirings, and the common signal is directly short-circuited between the sockets by using a short-circuiting plate to shorten the length of the wirings, thereby enhancing the immunity to noises.

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The Japanese Published Unexamined Patent Publication No.Hei 11(1999)-40294 discloses a technique that reduces the number of through holes and contacts to be formed on a printed circuit board by using a common bar as a common signal line between the sockets for memory modules, to thereby achieve simplification of the connector structure and reduction of the mounting cost.

The Japanese Published Unexamined Patent Publication No.Hei 10(1998)-335546 discloses a technique that achieves the electrical connection and mechanical support of modules only by a socket member having plural connections in pursuit of a size reduction of the socket that mounts plural modules. The technique achieves the compatibility of the mechanical holding power of the socket member and the overcoat plating facility on the electric contacts of the socket member, by shifting the positions of the contacts of external connection terminals on the front and back sides of the module.

The Japanese Published Unexamined Patent Publication No.Hei 8(1996)-314800 discloses a module for connecting memory modules that possesses plural connection sockets in order to connect the memory modules whose number exceeds the number of the sockets for the memory modules in a computer.

The Japanese Published Unexamined Patent Publication No.Hei 4(1992)-144160 discloses a memory array mechanism that connects a multi-layer board having memory modules mounted

thereon as a mutual connection member to the module board so as to face each other with a narrow gap through edge clips.

#### SUMMARY OF THE INVENTION

In a memory system mounting plural memory modules, the influence given to signal waveforms (deformations of waveforms by reflected waves due to the impedance mismatching) by the length of bus lines on a mother board and the number of the sockets for the memory modules on the bus lines has been an ignorable factor in a synchronous DRAM of which clock frequency exceeds 133MHz.

Especially, in a bus having multiple slots, the degree of influence to the waveforms that the reflected waves give at the termination greatly differs at the socket near side or at the socket far side, which makes the timing design difficult. And, as the number of the sockets increases, the length of the bus wiring becomes longer, and the wiring capacity increases, which makes it unfit for a high speed operation. Therefore, a shorter bus wiring with a shorter distance between the sockets in addition will achieve a better characteristic.

Accordingly, in this type of memory system, it is essential to design the bus wirings for the memory modules as shorter as possible to comply with a higher speed operation. However, the length of the bus wiring is basically determined

by the larger one of the thickness of the socket and that of the module and the number of the socket. As to the thickness of the module, the maximum thickness is settled by JEDEC, and as the result, if the specifications are the same, the widths of the buses will be virtually the same in any products.

Now, the inventor clarified the followings, through the examination of the memory system that mounts the plural memory modules as mentioned above. The technique of the memory system that the inventor examined will be discussed with reference to Fig.12 illustrating the structure of the memory system as the premise of the invention, Fig.13 illustrating the signal system of the memory system, and Fig.14(a), Fig.14(b) illustrating the signal waveforms that the memory modules receive.

As shown in Fig.12, in the memory system, for example, a memory controller 101 is directly mounted on a mother board 108, and three memory modules 102 to 104 each having memory IC are mounted in parallel on the mother board 108 through sockets 105 to 107 each having plural socket pins. By way of the bus wirings on the mother board 108, each of the memory modules 102 to 104 is connected electrically to the memory controller 101 through the socket pins of each of the sockets 105 to 107.

In this type of the memory system, from the viewpoint of pursuing a high speed, the influence by the length of the bus wiring becomes ignorable; however, in the parallel arrangement of the memory modules 102 to 104 as shown in Fig.12, there is





Thus, in the memory system as the premise of this invention, when the memory controller 101 sends a signal to each of the memory modules 102 to 104 as shown in Fig.14(a), with the reflected waves taken into consideration, the signals received by each of the memory modules 102 to 104 become, for example, the waveforms as shown in Fig. 14(b). Therefore, it is conceivable that the differences of the distances to each of the memory modules 102 to 104 viewed from the memory controller 101 create the following problems on the bus wirings.

(1) creating the differences of the signal arrival times (skew) due to the differences of the distances to reduce the margin of the timing.

(2) except for the memory module at the termination, the modules have stepped waveforms formed by the times for awaiting the reflected waves; in a signal that defines the timing of a signal with the value of half the amplitude, the timing errors are created to thereby reduce the timing margin. In order to resolve the stepped waveforms, there is a method of connecting a terminating resistor at the termination of the bus line to let the reflected waves loose (escape). But then, the voltage increases by the reflected waves disappear, and there appear the demerits: (1) a decrease of the voltage amplitude, and (2) an increase of the current consumption, which cannot be a desirable method.

Then, the inventor came to an idea to resolve the above







controller

$$< (\text{thickness of memory module board} + \text{thickness of mounted memory IC}) \times (\text{number of the memory modules} - 1).$$

Thereby, the memory system is able to suppress differences of signal arrival times due to differences of distances, and timing errors by reflected waves.

In accordance with another aspect of the invention, the memory system includes a board, a memory controller laid out on the board, and a socket laid out on the board, on which plural memory modules can be mounted. Thereby, the memory controller is made to connect in an equal distance to each of the plural memory modules to be mounted on the socket.

In accordance with another aspect of the invention, the memory system includes a board, a memory controller laid out on the board, and a connecting member laid out on the board, which includes a first mounting slot having a plurality of first terminals and a second mounting slot having a plurality of second terminals. And, a first memory module can be mounted on the first mounting slot so as to connect a plurality of the first terminals of the first mounting slot to a plurality of a third terminals of the first module, and a second memory module can be mounted on the second mounting slot so as to connect a plurality of the second terminals of the second mounting slot to a plurality of a fourth terminals of the second module. And thereby, a wiring distance between the memory controller and

one terminal of a plurality of the first terminals is made to be substantially equal to a wiring distance between the memory controller and one terminal of a plurality of the second terminals corresponding to the one terminal of the first terminals.

In accordance with another aspect of the invention, the memory system includes a board, a control device laid out on the board, having a first terminal, a connecting member laid out on the board, which includes a first mounting part having a second terminal and a second mounting part having a third terminal corresponding to the second terminal. Also, a first memory module can be mounted on the first mounting part, a second memory module can be mounted on the second mounting part, the first memory module has a fourth terminal, the second memory module has a fifth terminal, when the first memory module is mounted on the first mounting part, the second terminal is connected to the fourth terminal, and when the second memory module is mounted on the second mounting part, the third terminal is connected to the fifth terminal. Thereby, the shortest distance of wirings between the first terminal of the control device and the second terminal of the first mounting part is made to be substantially equal to the shortest distance of wirings between the first terminal of the control device and the third terminal of the second mounting part.

Further, the connecting member according to the invention

includes a first mounting part having a first terminal, a second mounting part having a second terminal corresponding to the first terminal, and a third terminal. And, a first memory module can be mounted on the first mounting part, a second memory module can be mounted on the second mounting part, the first memory module has a fourth terminal, the second memory module has a fifth terminal corresponding to the fourth terminal, when the first memory module is mounted on the first mounting part, the first terminal is connected to the fourth terminal, when the second memory module is mounted on the second mounting part, the second terminal is connected to the fifth terminal, the third terminal is connected to the first terminal of the first mounting part by a first wiring member, and the third terminal is connected to the second terminal of the second mounting part by a second wiring member, whereby a length of the first wiring member is made equal to a length of the second wiring member.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a schematic sectional view illustrating a structure of a memory system relating to an embodiment 1 of the invention;

Fig.2 is a schematic perspective view illustrating a state in which memory modules are mounted on a mother board through a socket, in the memory system relating to the embodiment 1 of the invention;

Fig.3 is an appearance view illustrating a state in which memory modules are mounted on the socket, in the memory system relating to the embodiment 1 of the invention;

Fig.4(a) and Fig.4(b) are schematic sectional views illustrating a pin structure of the socket, in the memory system relating to the embodiment 1 of the invention;

Fig.5 is an appearance view illustrating a shape of pins, in the memory system relating to the embodiment 1 of the invention;

Fig.6(a) and Fig.6(b) are schematic sectional views illustrating another pin structure of the socket, in the memory system relating to the embodiment 1 of the invention;

Fig.7 is an appearance view illustrating another shape of pins, in the memory system relating to the embodiment 1 of the invention;

Fig.8 is an explanatory chart illustrating a signal system of the memory system relating to the embodiment 1 of the invention;

Fig.9 is an explanatory chart illustrating the internal configuration and signal system of the memory modules, in the memory system relating to the embodiment 1 of the invention;

Fig.10 is a schematic sectional view illustrating a structure of the memory system relating to an embodiment 2 of the invention;

Fig.11 is a schematic drawing illustrating a structure

of the memory system relating to an embodiment 3 of the invention;

on a mother board through a socket, in the memory system of this embodiment, Fig.3 an appearance view illustrating a state in which the memory modules are mounted on the socket, Fig. 4(a) and Fig. 4(b) a schematic sectional view illustrating a pin structure of the socket (the sectional view is omitted on the drawing), Fig.5 an appearance view illustrating a shape of pins, Fig.6(a) and Fig.6(b) a schematic sectional view illustrating another pin structure of the socket (the sectional view is omitted on the drawing), Fig.7 an appearance view illustrating another shape of pins, Fig.8 an explanatory chart illustrating a signal system of the memory system, Fig.9 an explanatory chart illustrating the internal configuration and signal system of the memory modules, and Fig.15(a) and Fig.15(b) a waveform chart illustrating the write data to the memory IC.

First, a configuration of the memory system of this embodiment will be described with reference to Fig.1 to Fig.3. The memory system of this embodiment is defined as a memory system having plural (three, in this example) memory modules mounted thereon. The memory system includes a memory controller 1, three memory modules 2 to 4, a socket 5 which the three memory modules 2 to 4 can be inserted into and pulled out from, and a mother board 6 on which the memory controller 1 and the socket 5 are mounted. And, the memory controller 1 and each of the memory modules 2 to 4 are connected in an equal distance through the socket pins of the socket 5 that are branched from





board-bus connections 10 common to the memory modules 2 to 4, by binding three module-board contacts 11 into one body at one board-bus connection 10; and Fig.6(b) and Fig.7 represent a socket pin 13 being the other type that separates the board-bus connections 10 with each of the memory modules 2 to 4, and has one module-board contact 11 to one board-bus connection 10.

The mother board 6 is a printed circuit board, on the front side of which, for example, the memory controller 1 and the socket 5 are mounted, and on the back side of which bus wiring 14 is formed. The mother board 6 is pierced through from the front side to the back by way of a via hole 15, and the pins of the memory controller 1 and the socket 5 are inserted from the front to the back, which are electrically connected to the bus wiring 14.

In the memory system thus constructed, the pins of the memory controller 1 and the socket 5 are inserted in the via hole 15 on the mother board 6, whereby the memory controller 1 and the socket 5 are mounted on the mother board 6. Further, three memory modules 2 to 4 are inserted in the socket 5, whereby three memory modules 2 to 4 are connected in a radial form to the mother board 6 and in an equal distance from the bus wirings 14 on the mother board 6.

This memory system satisfies the following relation owing to its structure.

(Difference of the distance between the nearest memory



the three module-board contacts 11 inside the socket 5 to arrive thereat. Therefore, the distances to each of the memory modules 2 to 4 from the memory controller 1 will not be different. Thereby, the wiring lengths to each of the memory modules 2 to 4 from the memory controller 1 will can be made equal, and the signal can be transmitted to each of the memory modules 2 to 4 at the same timing.

## (2) Signal System Independent to Each Module

The signal system independent to each module includes the clock signal: CK0 to CK8, clock management signal: CKE0 to CKE5, bank selecting signal: CS0 to CS5, power supply signal: Vdd, Vss, and so forth.

In this signal system independent to each of the memory modules 2 to 4, the memory system employs the socket pins 13 with the structure that has one module-board contact 11 to one board-bus connection 10, as shown in Fig.6(a), Fig.6(b) and Fig.7, whereby the memory modules 2 to 4 are connected to the bus wirings in one-to-one. Therefore, the wiring lengths from the memory controller 1 to each of the memory modules 2 to 4 can be made equal by adjusting the wiring lengths inside the bus wiring 14 or the socket 5. Thereby, the signal can be transmitted to each of the memory modules 2 to 4 at the same timing. Here, the power supply signal is frequently separated in pursuit of increasing the stability of the power supply, but

[illegible]

Next, an example of the inner configuration and the signal system of the memory modules 2 to 4 in this memory system will be described on the basis of Fig.9. This example employs a two-banks-form and a double data mode synchronous DRAM built-in module that incorporates 8 pieces of the memory IC 7 being the synchronous DRAM with 8 input/output terminals each on the front

[illegible]

(1) Address Signal

The address signal (A0 to A11) is a signal to designate an address that is specified by a Row and a Column of a memory matrix composed of plural memory cells disposed in a grid form, inside the synchronous DRAM. This address signal is commonly provided to the synchronous DRAM #0 to #15.

(2) Control Signal

The control signal includes a Row Address Strobe signal (RAS), Column Address Strobe signal (CAS), and Write Enable signal (WE), etc. The Row Address Strobe signal (RAS) is a strobe signal to determine the timing of fetching a row address signal. The Column Address Strobe signal (CAS) is a strobe signal to determine the timing of fetching a column address signal. The Write Enable signal (WE) is a switching signal to switch the write enable mode and the read enable mode. These control signals are commonly provided to the synchronous DRAM #0 to #15, in the same manner as the address signal.

### (3) Data Signal

The data signal (DQ0 to DQ63) is an output data in the read enable mode. The data signal (DQ0 to DQ7) is allocated to the synchronous DRAM #0, (DQ8 to DQ15) to the synchronous DRAM #1,..., and the (DQ56 to DQ63) to the synchronous DRAM #15, which are separately provided.

(4) Data Management Signal

The data management signal (data strobe signal: DQS0 to DQS15) is a strobe signal to determine the timing of data read. The data management signal (data mask signal: DM0 to DM15) is a mask signal to determine whether to or not to read a data. The data management signal (DQS0, DM0) is allocated to the synchronous DRAM #0 on the front side, (DQS1, DM1) to the synchronous DRAM #1, (DQS7, DM7) to the synchronous DRAM #7; and (DQS8, DM8) is allocated to the synchronous DRAM #8 on the back side, (DQS9, DM9) to the synchronous DRAM #9,..., (DQS15, DM15) to the synchronous DRAM #15, which are separately provided.

(5) Bank Selecting Signal

The bank selecting signal (chip selecting signal: CS0, CS1) is a signal to select a bank of the memory module. The bank selecting signal CS0 is allocated to the synchronous DRAM #0 to #7 each on the front side, CS1 is allocated to the synchronous DRAM #8 to #15 each on the back side.

In each of the memory modules 2 to 4 thus configured, the memory controller 1 controls the data read/write operation to each memory IC 7 of the synchronous DRAM. First, the address signal (A0 to A11) selects an arbitrary memory cell of a memory matrix of the memory IC 7 #0 to #15. At that moment, the Row Address Strobe signal (RAS), Column Address Strobe signal (CAS), and Write Enable signal (WE) control the various timings; and the bank selecting signals CS0, CS1 select the banks of each

of the memory modules 2 to 4.

And, in the write operation to a selected memory cell, the data signal (DQ0 to DQ63) is written in the memory cell as the write data. In the read operation from the selected memory cell, the data signal (DQ0 to DQ63) read from the memory cell is outputted as the read data. At that moment, the timing of data read is determined by the data strobe signal (DQS0 to DQS15) and the data mask signal (DM0 to DM15).

Next, in the memory system of this embodiment, when the memory controller 1 delivers a signal to each of the memory modules 2 to 4, with the reflected waves taken into consideration, if each of the memory modules 2 to 4 is located in an equal distance from the memory controller 1, all the memory modules 2 to 4 will receive the similar waveform to that of the memory module (3) as shown in Fig.14(a) and Fig.14(b).

Therefore, the memory system achieves:

- (1) restricting the differences of the signal arrival times (skew) due to the differences of the distances to secure the margin of the timing.
- (2) letting loose the reflected waveforms that form stepped waveforms, and restricting timing errors as to a signal that defines the timing of a signal with the value of half the amplitude to secure the margin of the timing. And, it is also conceivable to receive the reflected waves from the other modules, but the voltage has already risen by receiving the



reflected waves, the influence to the timing is limited.

Further, the memory system of this embodiment achieves shortening and equalizing the wiring lengths inside the socket 5, by gathering the socket pins 12, 13 to the center of the socket 5 in a radial shape, and also reducing the width along the bus direction of the socket 5. Therefore, the memory system exhibits the following effects.

(1) Since it allows the layout of three memory modules 2 to 4 on the bus wiring 14 on the mother board 6 in a single distance from the memory controller 1, the system is able to equalize the lengths of the signal lines to the memory modules 2 to 4 from the memory controller 1, and also able to supply the memory modules 2 to 4 with a signal of the same waveform at the same timing.

(2) Since it suppresses the stepped waveforms by the layout of each of the memory modules 2 to 4 in a single distance from the memory controller 1, the system is able to save the termination resistors for setting free the reflected waveforms being a factor to form the stepped waveforms. Therefore, as the simulation result shown in Fig. 15 ((a): with termination resistor, (b): without termination resistor), the system is immune to mutual influences from the positional differences of the slots even without the termination resistors, and the waveform of the write data to the memory IC rises/falls sharply; accordingly, the system secures a sufficient amplitude and





into and pulled out from, and a mother board 27 on which the memory controller 21 and the socket 26 are mounted. And, the four memory modules 22 to 25 are mounted in the socket 26 on the mother board 27 with two modules each up and down, so as to be in parallel to the mother board 27.

Therefore, in the memory system of this embodiment, while each of the memory modules 22 to 25 are mounted in parallel to the mother board 27, the memory controller 21 and each of the memory modules 22 to 25 are connected in an equal distance through the socket pins of the socket 26 that are branched from bus wirings on the mother board 27; and the memory system achieves the same effect as in the embodiment 1 accordingly. Especially, for a space with a vertically limited height on the mother board 27, the memory system of this embodiment will display the effect to this space for mounting.

[Embodiment 3]

Fig.11 is a schematic sectional view illustrating a structure of the memory system of an embodiment 3. The memory system of this embodiment is defined as a memory system having plural memory modules mounted thereon, which is the same as the one in the embodiment 1 and the embodiment 2, and the difference from the one in the embodiment 1 and the embodiment 2 lies in modifying mother board and socket structures, and using the socket for mounting the memory modules so as to branch the memory

modules multiply within the angle of  $360^\circ$  to the mother board.

That is, as shown in Fig. 11, the memory system of this embodiment includes a mother board 33 on which a memory controller 31 and a CPU 32 are mounted, 8 memory modules 34 to 41, a socket 42 which the mother board 33 and the memory modules 34 to 41 can be inserted into and pulled out from. And, the mother board 33 is mounted on a slot of the socket 42, and the memory modules 34 to 41 are mounted on the other slots so as to branch the memory modules 34 to 41 multiply in an equal angle within the angle of  $360^\circ$ .

Therefore, in the memory system of this embodiment, while the connecting configurations of the mother board 33 and each of the memory modules 34 to 41 through the socket 42 are different, the memory controller 31 and each of the memory modules 34 to 41 are connected in an equal distance through the socket pins of the socket 42 that is placed on one end of the mother board 33; and the memory system attains the same effect as in the embodiment 1 and embodiment 2. Especially, in this embodiment, by branching the memory modules multiply within the angle of  $360^\circ$  to the mother board 33, it is possible to connect a lot of memory modules to the memory controller 31 in an equal and shortest distance. Since the socket 42 is located on the end of the mother board 33, the mounting number can be increased with the same bus wiring length.

The present invention by the inventor has concretely been

described on the basis of the preferred embodiments given herein, however it should be understood that the invention is not limited to the aforementioned embodiments, and various changes and modifications are possible without departing the scope and spirit thereof.

For example, in the embodiment 1, the system may take on two or more than four memory modules instead of three; in the embodiment 2, the system may take on two, three or more than five memory modules instead of four; and in the embodiment 3, the system may take on two through seven or more than nine memory modules instead of eight.

Further, in the foregoing embodiments, the memory system is assumed to take on a two-banks-form synchronous DRAM incorporated module having a 64-bits input/output terminal configuration for each of the memory modules, however the other input/output terminal configurations and the other bank forms can be applicable, and a general purpose DRAM or other memories can be widely adopted.

Furthermore, the memory system of the invention can be applied generally to the system that requires a higher speed of the memory, and it is effective for use in a high-speed disk top PC, a memory board for a high-speed sophisticated server, and so forth. The typical effects achieved by the invention disclosed herein are as follows.

- (1) By connecting the wirings on the mother board to the

plural memory modules on the module boards with the socket having the plural socket pins that are branched from one point, the memory system shortens and equalizes the wiring lengths inside the socket, also reduces the width along the bus direction of the socket, and thereby enables connecting the memory controller to each of the memory modules in an equal distance.

(2) Since the plural memory modules can be placed in a signal distance from the memory controller with the wirings on the mother board, it becomes possible to input a same waveform signal at a same timing to the plural memory modules.

(3) Since the number of the sockets to be mounted on the mother board can be reduced, and the wiring length from the memory controller to each of the memory modules can be shortened, the memory system is applicable for a high-speed signal.

(4) By mounting each of the memory modules in a radial form on the mother board, the upper area to the surface mounting components on the mother board can be utilized as a space to install the memory modules, and the high-density mounting onto the mother board becomes possible.

(5) Since the stepped waveforms can be reduced by the layout of each of the memory modules in a single distance from the memory controller, it is possible to eliminate the termination resistors for setting free the reflected waveforms being a factor to form the stepped waveforms, or to reduce the

number of the termination resistors, or to increase the resistances of the termination resistors. As the result, the system reduces the currents consumed across the termination resistors, expands the timing margin by shortening the transit time for the rising/falling of the signal waveform, and also expands the signal voltage margin by the increase of the signal amplitude.

(6) Satisfying the relation:

(Difference of the distance between the nearest memory module and the farthest memory module, viewed from the memory controller)  $<$  (thickness of memory module board + thickness of mounted memory IC)  $\times$  (number of the memory modules - 1), it is possible to suppress the differences of the signal arrival times due to the differences of the distances, and the timing errors by the reflected waveforms, whereby the timing margin can be secured.